CRUISE REPORT
C-109

Scientific Activities
Undertaken Aboard SSV Corwith Cramer

St. Thomas - Carriacou - Grenada - Roatan - Cozumel - Miami

30 November 1989 - 10 January 1990

Sea Education Association - Woods Hole, Massachusetts

Winds. To blow us down and then
to bring us home.
To blow us back unto ourselves.
Fill our sails and brim our hearts.
Full to bursting. The sea accepts,
widens our reception.
We are overflowing and the sea
contains us.
And then when we are stretched,
when we are broadened,
opened up to new life,
the sea gives us back to ourselves.

~ Susan St. John Rheault

PREFACE

This cruise report is a partial record of the formal education and scientific activities conducted during the sea component with SEA Class 109 on the SSV Corwith Cramer. The emphasis is on the formally scheduled activities, the scientific sampling, the laboratory analyses and student research projects. For those who experienced C-109 it is of course an incomplete reflection of all that transpired and all that was learned. An accurate characterization of C-109 would have to clarify in detail the intensity and diversity of the educational experiences. While a great deal of science and seamanship has been acquired by the entire class, many of the other lessons have been rooted in the character of each individual student. Most are aware of some of the personal growth gained during the cruise; other lessons learned will only be appreciated at a much later date. The ambitions, dreams, hopes and ideas that Cory Cramer believed in and made possible through his creation of the Sea Semester Program have been more than substantially realized during C-109. The character of each student and their view of the world and themselves have certainly grown rapidly over the six weeks on SSV Corwith Cramer.

It has been a pleasure to serve as Chief Scientist for C-109. May many more successful Sea Semesters follow this one.

A note of special thanks to Dyann Curtis provides recognition for her typing of this report and setting up all the data tables in the appendices.

Charles E. McClennen
Professor of Geology
Colgate University

Sea Fever

I must go down to the seas again,
to the lonely sea and the sky,
And all I ask is a tall ship
and a star to steer her by;
And the wheel's kick and the wind's song
and the white sails shaking,
And a grey mist on the sea's face,
and a grey dawn breaking.
I must go down to the seas again,
for the call of the running tide
Is a wild call and a clear call
that may not be denied;
And all I ask is a windy day
with the white clouds flying,
And the flung spray and the blown spume,
and the seagulls crying.
I must go down to the seas again,
to the vagrant gypsy life,
To the gulls way and the whale's way
where the wind's like a whetted knife;
And all I ask is a merry yarn
from a laughing fellow rover,
And a quiet sleep and a sweet dream
when the long trick's over.

~ John Masefield

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INTRODUCTION

Cruise C-109 differed from most Sea Semesters in that the chief scientist was not involved with the shore component nor a regular SEA staff member. However, the initial development of student research projects was ably directed by Charles E. Lea of SEA. Furthermore, the participation of Jerry Cheney on the first leg in combination with the experienced assistant scientists, Tim Kenna and Nicki Villars, provided a strong basis for the instruction on field sampling, laboratory analyses, and cruise procedures. Ed Lyman's dedication to learning all laboratory practices prior to standing watch was equally impressive and valuable to the success of the science conducted during the cruise. The strong, cooperative, and spirited leadership of Peg Brandon, Master, provided continuity and a high quality nautical science and deck support for the student projects. The attitude, energy, and knowledge of the mates, engineer, and steward were similarly wonderful and valuable for the whole enterprise. Each provided individualistic, responsible, and often humor-laced service without hesitation. Overall a better or more cooperative crew would be hard to assemble or imagine.

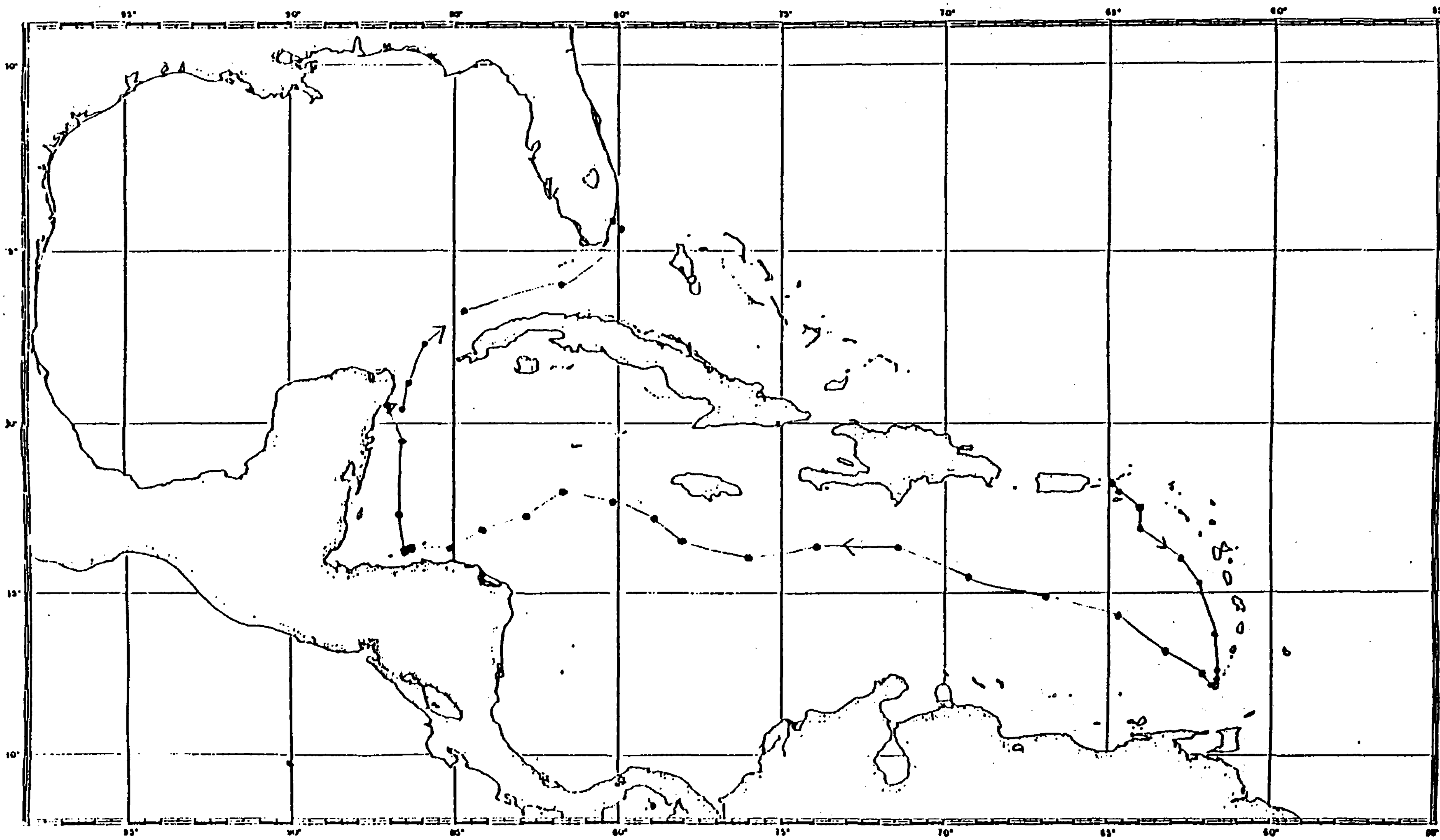
Similarly the weather was generally supportive of the cruise plan and sampling needs. So given the good vessel, Corwith Cramer, the able and dedicated staff, and a good class of students, a good deal was accomplished on each of the three legs, as well as during the port stops.

Leg I from St. Thomas to Carriacou and Grenada enabled the students to gather essential data for several projects. The sampling consisted of twenty-three surface stations with twenty-one EBT or MBT's and thirty-three stations consisting of 5 hydrocasts (36 bottles), 7 CTD deployments, 9 neuston net tows and 12 meter net tows. Beach, reef and Sandy Island sampling at the end of Leg I supported 5 additional projects. The port stops also enabled the lab watches to complete Leg I water chemistry analyses.

Leg II was typified by the expected tail winds until a strong cold front penetrated the Caribbean and stalled out during Christmas Eve day and the subsequent 5 days. With a lower density of sampling planned for Leg II, the stormy weather only reduced water and bottom sampling somewhat around Pedro Bank and on the Honduran Shelf. The hydro-winch electrical failure was traced-out, located and ably repaired under the leadership of SSV Westward Master, Ron Harelstad. This visit and service turned C-109 from gloom to fully operating joy (stick). Strong winds made hydrocast wire angles a critical problem for the deeper stations with target depths of 1800 M. Sampling at sea consisted of 21 surface and EBT stations, 13 CTD casts, 6 hydrocasts, 13 meter net tows, 21 neuston net tows, 17 phytoplankton tows and 16 shipek grab-sample casts. Roatan, our port stop after Leg II, provided additional beach and reef sampling opportunities, as well as time to complete chemical analysis of water samples.

Leg III had minimal sampling so as to enable a thorough student writing, editorial review, and rewriting of the research papers, as well as their oral presentations. A one and a half day port stop in Cozumel (to pick up Joan Mitchell, an NSF representative) facilitated project analyses and some writing efforts. Continued sampling for SEA data banks consisted of 2 hydrocasts, 5 EBT's, 6 CTD's, 2 meter net tows, and 5 neuston net tows.

C-109 CRUISE TRACK CHART



STAFF LIST

Captain & Academic Coordinator	Peg Brandon
First Mate	Jeff Stone
Second Mate	Zach Thomas
Third Mate	Cindy Smith
Engineer	Gioia Blix
Steward	Kathy Meagher
Chief Scientist	Charlie McClennen
First Assistant Scientist	Tim Kenna
Second Assistant Scientist	Nicki Villars
Third Assistant Scientist	Ed Lyman
Visiting Head Scientist (Leg I)	Jerry Cheney
Visiting NSF Representative (Cozumel to Miami)	Joan Mitchell

STUDENT LIST

Deborah H. Arin	Univ. of Massachusetts	English
Kenneth C. (Scott) Avanzino	Colgate	Geology
Theresa A. Bissell	DePauw	Biology
Kerry A. Dorton	St. Lawrence	Undeclared
Amy E. Dubois	Rutgers	Biology
Benjamin C. (Clay) Gentry	Univ. of Alabama	Undeclared
Jennifer L. Haddock	U.R.I.	Ocean Engineering
Kendal E. Harr	Cornell	Animal Sciences
Kimberly S. Jaussi	Smith	Economics
Scott T. (Scully) Kelley	Cornell	Biology
Christopher W. Knowlton	Colgate	Chemistry
William J. Leazer	Purdue	Undeclared
Lydia M. Lien	Colorado College	Undeclared
Alison McKersie	Cornell	Labor Relations
Katherine L. Mansfield	Mt. Holyoke	Biology
Laura A. Moorehouse	RI School of Design	Illustration
Steven B. Seibel	Beloit	Physics
Delius B. Shirley	Colgate	Undeclared
Francesca A. Smith	Yale	Biology
Frederick J. Stewart	Colby	Art History
Diana L. Stram	Colgate	Geology
Elizabeth A. Swanson	Fairfield University	Biology
Rachel G. Tilney	Colby	Sociology
John K. Ugoretz	UC Berkeley	Marine Biology
Robert B. Watters	Denison	Undeclared

ACADEMIC PROGRAM

The academic program during C-109 was composed of many elements. The daily patterns and responsibility of standing deck, engineer, and science watch provided innumerable lessons for conducting science at sea. The twenty-four hour-a-day operation of the ship by students and staff similarly infused endless instruction into the life of the students. More structured learning and academic activities are indicated by the lists of scheduled classes and student presentations. The Practical Oceanography classes were presented by the chief and assistant scientists roughly five days a week. The Master, mates and engineer similarly provided a series of Nautical Science classes. The students had a parallel set of brief presentations, which they prepared, for both oceanography and nautical science topics. These were titled Feature Creature Presentations and Primate Symposium respectively. The dates, speakers, and topics of these four formal aspects of the academic program are listed below. At the end of the cruise all class time was dedicated to the final oral reports for each student research project listed under the section on the Research Program which follows this Academic Program section.

1. Practical Oceanography Classes

Date	Topic	Speaker
12/1	Orientation: Sea Component Overview; Goals and Objectives of Leg I & Cruise	Charlie McClennen
12/2	Neuston Net Tow and 5 Bottle/CTD Hydrocast Demonstration	Jerry Cheney & Tim Kenna
12/3	Deployment, Recovery, and Processing of Meter Net Tows	Tim Kenna
12/4	Crustacean Biology, Classification and Identification	Tim Kenna
12/5	Oceanic Feeding Relationships & The Remodeled Food Web	Jerry Cheney
12/6	Marine Sediment Classification, Origin and Processes	Charlie McClennen
12/7	Coral Reef Ecology and Zonation	Ed Lyman
12/8	Chemical Analytical Principles and At-Sea Procedures	Jerry Cheney
12/12	Leg II Oceanography Sampling Plan & Projects	Charlie McClennen
12/13	Demonstration of Secchi disc & Deep Hydrocast	Science Staff
12/14	Sediment Analysis and Sampling Techniques	Charlie McClennen

12/15	Oceanography Laboratory Analysis and Sampling Procedures Test	Science Staff
12/18	Caribbean Water Masses: Characterization, Sources & Circulation	Charlie McClennen
12/20	Caribbean Tectonic History & Development	Charlie McClennen
12/21	Geologic Nature of Caribbean Ridges, Rises & Banks, including Development & Present Processes	Nicki Villars
12/22	Carbonate Banks and Reef Sediment Transport	Tim Kenna
12/23	Practical Oceanography I Final Exam	Charlie McClennen
12/26	Isthmus of Panama, The Gulf Stream, Climate Change & The Evolution of Man	Charlie McClennen
1/1	Preparation and Presentation of Scientific Research Results - Discussion	Charlie McClennen & Students
1/2	Six Student Talks	
1/4	Six Student Talks	
1/5	Six Student Talks	
1/6	Seven Student Talks	
1/8	Final Exam for Practical Oceanography II	Charlie McClennen

2. Nautical Science Class

Date	Topic	Speaker
11/30	Safety Drills & Stations	Peg Brandon
12/1	Introduction to Cruise Programs	Peg Brandon
12/2	Drills	Peg Brandon
12/4	Man Overboard	Peg Brandon
12/5	Bos'n Duties & Functions	Zach Thomas
12/6	Maneuvers	Peg Brandon
12/8	Medical Concerns & Procedures	Tim Kenna
12/12	Line Relays	Staff
12/14	Sail Drills	Peg Brandon
12/15	Fire Fighting Instruction	Gioia Blix
12/18	Stars & Navigation	Jeff Stone
12/19	Radar & Navigation	Jeff Stone
12/21	Rules of the Road	Zach Thomas
12/22	Rules of the Road	Zach Thomas
12/26	Phase III Instruction	Peg Brandon

3. Feature Creature Presentations

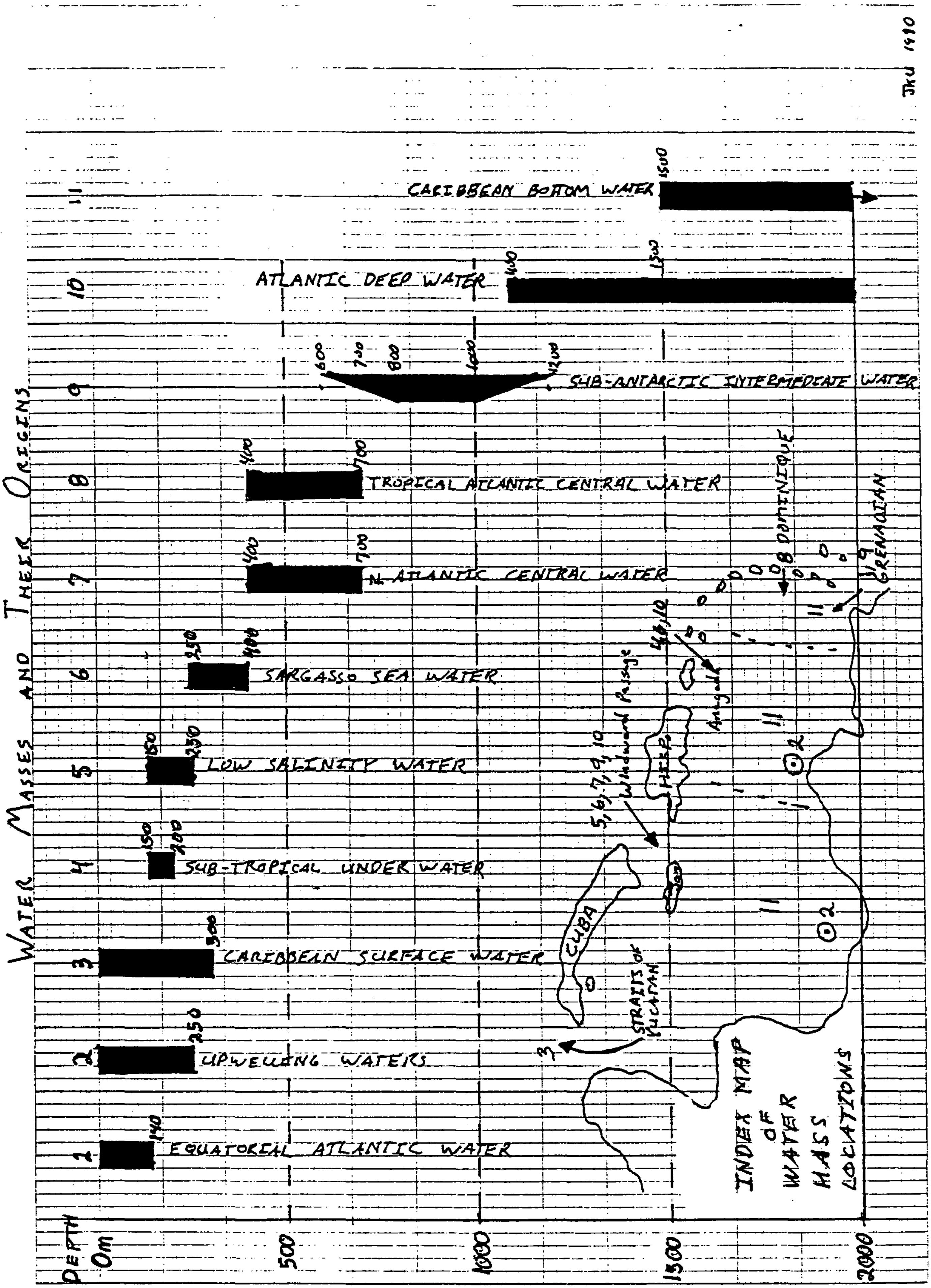
Date	Topic	Students
12/13	Flying Fish	John & Rachel
	Portuguese Man O'War	Amy & Delius
12/14	Brown Boobies	Diane & Kim
	Shrimp	Bill & Kendal
12/18	Dolphin, Mammal	Fred & Rob
	Lantern Fish	Katie & Kerry
12/19	Barnacles	Debbie & Scully
	Bioluminescence	Ali, Clay & Laura
12/21	Euphausids	Liz & Steve
	Siphonophores	Jen & Theresa
12/22	Green Turtles	Francesca & Lydia
	Dolphin fish	Chris & Scott

4. Primate Symposium Presentations

Date	Topic	Students
12/13	Halon Chemistry & System	Francesca & Jen
12/14	International Code Flags	Chris & Laura
12/15	Antennas	Scully, Steve & Theresa
12/18	Fuel Systems	Bill & Liz
12/19	Emergency Steering Gear	Debbie & Rachel
12/21	Ground Tackle	Amy & Kendal
12/22	Life Rafts & Emergency Gear	Ali & Lydia
12/23	Ventilation	Delius & Kim
12/26	Refrigeration	Clay & Diana
12/27	Propeller & Shaft	Rob & Scott
12/28	Storage Areas	Katie & Kerry
12/29	Batteries	Fred & John

THE RESEARCH PROGRAM

The energetic and ambitious leadership of Charles E. Lea in setting up the student research projects during the shore component gave the cruise clear direction and a challenge. The goal was to understand the nature and interaction of the numerous water masses as they enter, reside within the Caribbean Sea and depart, and how they influence biogeography, chemistry, sedimentation, and water circulation. The water masses provide clues for an improved understanding of the Caribbean Sea dynamics. Examination of island coasts, reefs, carbonate banks and continental margin sediments similarly provide windows through which to view oceanographic processes and products within the Caribbean Sea. Each of the student projects examines one or more elements of this dynamic system. Often the projects were designed to build on previous SEA research efforts and improve both our understanding as well as our sampling and analysis methods. The following figure indicates numerous published characteristics of the water masses present in the Caribbean.


WATER MASSES AND THEIR ORIGINS
JKU 1990
1 EQUATORIAL ATLANTIC WATER 140
2 UPWELLING WATERS 250
3 CARIBBEAN SURFACE WATER 300
4 SUB-TROPICAL UNDER WATER 150 200
5 LOW SALINITY WATER 150 250
6 SARGASSO SEA WATER 250 400
7 N. ATLANTIC CENTRAL WATER 400 700
8 TROPICAL ATLANTIC CENTRAL WATER 400 700
9 SUB-ANTARCTIC INTERMEDIATE WATER 600 700 800 1000 1200
10 ATLANTIC DEEP WATER 1100 1500
11 CARIBBEAN BOTTOM WATER 1500
DEPTH 0m 500 1000 1500 2000
INDEX MAP OF WATER MASS LOCATIONS
CUBA
HISP.
STRAITS OF YUCATAN
5,6,7,9,10 Windward Passage
4,8,10
Anegada
8 DOMINIQUE
9 GRENADIAN
3
2
11

Student Research Project Management

In order to facilitate the execution of each and every student research project, a sequence of activities and deadlines was established for C-109. This enabled the students to proceed at a reasonable pace while attending to their other watch responsibilities. The coordinated program of advice, activities and deadlines also significantly influenced the quality of the final research papers and the abstracts included in this cruise report.

1. Prior to each leg and port stop, all students submitted a written statement of their research needs specifying sample location, time of day, equipment, methods, and analyses.

2. For each leg, the sampling plan was posted in the laboratory so that all watch standers could see at a glance what had been done, what was coming up next, and where the stations were to be located.

3. Each student was paired with an assistant scientist who served as research advisor. An attempt was made to match the research topics with the special expertise and experience of the assistant scientists.

4. During the first three weeks, the students were strongly encouraged to revise the Introduction and Methods sections of their proposals so as to reflect the changes which developed during the course of sampling and analysis.

5. A set of instructions for scientific paper format, content and emphasis was posted in the laboratory at the beginning of the third week.

6. At the end of the third week, a one- to two-page progress report on each student project was required, in typed form. This enabled each student to become familiar with computers prior to the anticipated end-of-cruise crunch. It also provided the basis for a joint assessment between each student and advisor as to the best way to complete the project during the cruise. The progress report and effort were graded components for the Practical Oceanography I course.

7. During the fifth week, a full class was spent discussing the aspects, content, elements, etc. needed for a quality oral presentation of the research projects. A carefully worded summary of key ideas, concerns, tips, as well as a list of "do's" and "don'ts" was posted in the laboratory for all to study.

8. In the middle of the fifth week, a "nearly completed" draft of the student research paper was due for the assistant scientists to edit and review.

9. Each student paper was edited and reviewed by at least two students during the final week. Each student edited at least two papers. This proved to be very valuable for authors and editors alike, while significantly improving the quality of student writing.

10. The 15-minute oral presentations, with five or more minutes for discussion of each report were scheduled over a four-day period (~6 projects per day) into two sessions separated by a snack or break of several hours.

11. The final revised papers were due the day after the talks were completed and a day before the Practical Oceanography II final exam. The announced focus of the final exam was the research reports and an overall synthesis of the cruise research program.

Student Research Project Titles

1. Arin, Debbie & Jaussi, Kim	Univ. of Mass. Smith College	Pelagic Plastics: Distribution in the Caribbean Sea and in the Intertidal Zones of Carriacou and Roatan.
2. Avanzino, Kenneth Jr.	Colgate Univ.	An Exploration and Comparison of the Mixture and Grain Size Distribution of Terrigenous and Carbonate Sediments along the Continental Slope off Cape Cameron, Honduras.
3. Bissell, Theresa	DePauw Univ.	A Descriptive Analysis of Temperatures in the Caribbean Sea.
4. Dorton, Kerry A. & Harr, Kendal	St. Lawrence Cornell Univ.	The Density and Distribution of Oscillatoria and its Importance as a Primary Producer in the Caribbean Sea.
5. DuBois, Amy	Rutgers Univ.	Diel Vertical Migration: Biomass and Diversity of Zooplankton off the Leeward Side of Grenada.
6. Gregory, B. Clayton	U. of Alabama	Sediment Study of the Southern Flank of Pedro Bank.
7. Haddock, Jennifer L.	U.R.I.	Geostrophic Flow through the Lesser Antilles.

8. Kelley, Scott	Cornell Univ.	A Comparison of the Location and Concentration of the Deep Chlorophyll Maximum in Near-Island, Open Ocean, and Carbonate Bank Waters.
9. Knowlton, Christopher	Colgate Univ.	The Occurrence of North Atlantic Deep Water in the Caribbean Sea.
10. Leazer, William	Purdue Univ.	Zooplankton Biomass vs. Diversity in the Caribbean Sea.
11. Lien, Lydia	Colorado Coll.	Distribution of Pelagic Tar in the Caribbean.
12. Mansfield, Kate	Mt. Holyoke	The Distribution of <u>Gambierdiscus</u> <u>Toxicus</u> Found on Various Species of Algae in the Shallow Water Coral Reefs of Sandy Island and Carriacou.
13. McKersie, Alison	Cornell Univ.	A Study of the Distribution of Scotch-Tape Larval Forms in the Caribbean Sea.
14. Moorehouse, Laura	RI Sch. Design	Pigmentation of Zooplankton in Relation to Diel Vertical Migration.
15. Seibel, Steve	Beloit College	The Location and Profile of Subtropical Underwater Along the C-109 Cruise Track.
16. Shirley, Delius & Ugoretz, John	Colgate Univ. UC - Berkeley	An Examination of Coral Zonation and Diversity in Comparison with Sedimentation and Depth on Two Caribbean Islands.
17. Smith, Francesca A.	Yale	Zoogeographic Distribution of Euthecosomatous Pteropods in the Eastern Caribbean Sea.
18. Stewart, Frederick	Colby College	A Study of Antarctic Intermediate Water at Various Locations in the Caribbean Sea.
19. Stram, Diana & Tilney, Rachel	Colgate Univ. Colby College	Sandy Island, Carriacou: An Exploratory Study of the Forces Affecting the Sedimentary Processes.
20. Swanson, Elizabeth	Fairfield Univ.	Concentration of Chlorophyll A and Phosphate: Two Determinants of Productivity over Pedro Bank.
21.Watters, Robert	Denison Univ.	How Source Waters Entering the Caribbean Sea Affect the Distribution and Abundance of <u>Halobates</u> <u>Micans</u>.

STUDENT PAPER ABSTRACTS

Pelagic Plastics: Distribution in the Caribbean Sea and in the Intertidal Zones of Carriacou and Roatan

Debbie Arin, University of Massachusetts
Kim Jaussi, Smith College

Abstract:

Pelagic plastics were sampled throughout the C-109 cruise track and on the islands of Carriacou and Roatan. An east to west increase throughout the cruise track was expected. A higher level of plastic deposition on Roatan than on Carriacou was also hypothesized. Increased use of plastic as a packaging methods prompted an expected correlating increase in levels from prior cruises. Pellets were also expected to be the highest percentage of types of plastic found.

A neuston net was used to sample surface waters, and beach transects as well as walking transects were used as sampling techniques on the islands. The neuston samples were sieved and subsampled for plastic. The beach transect samples were brought to the vessel and plastic particles were floated out.

Overall, the results of this study do not indicate an increase in plastics. Overall levels are consistent with past S.E.A. data collected; however, the percentage of pellets was greatly decreased. In the neuston tows, the mean number of pellets collected per tow was .13, versus C-103's mean of .29. Furthermore, data gathered from cruises W-78 to C-106 yielded an average of 22 pellets per tow in the Caribbean Sea. The hypothesis of east to west transport was confirmed, as Roatan yielded an average of 71 pieces per transect, while Carriacou yielded an average of 15. The greatest percentage of plastics found on both land and at sea on this cruise was classified as "chunks". "Chunks" consist of any three dimensional, non-flexible article of plastic. In addition to these findings, plastic was found on both the north and south sides of Roatan, while only on the windward side of Carriacou.

Future studies should perhaps focus on beach and reef topography because this study found the distribution of plastics on Roatan and Carriacou to be highly variable, dependent on wave breaks, wind and storm patterns, and apparent topographical differences of the beaches sampled. This occurrence of patchiness has been noted previously but never specifically studied at S.E.A..

An Exploration and Comparison of the Mixture and Grain Size Distribution of Terrigenous and Carbonate Sediments along the Continental Slope off Cape Cameron, Honduras

Kenneth C. Avanzino, Jr., Colgate University

Abstract:

The focus of this project was to compare the composition and grain size of sediments along the continental slope off Cape Cameron, Honduras and relate them to the depositional processes active in the area.

Four bottom sediment samples were collected between depths of 760 and 300m along the Honduran continental slope. Grain size and compositional analyses indicated the existence of the outer margin of a delta system, with well sorted, fine clay blanketing a large portion of the slope features. The Rio Negro was responsible for transporting fine grained clays, silts and detrital remnants from the mainland to the outer portions of the upper continental slope. Foraminifera dominated the carbonate fraction of sediments and showed a higher percentage further upslope, most likely due to dilution by terrigenous sediments forming the delta.

A Descriptive Analysis of Temperatures in the Caribbean Sea

Theresa Bissell, DePauw University

Abstract:

The purpose of this project was to describe the changes in the temperature from north to south along the Lesser Antilles and also east to west across the Caribbean Sea. All data were collected using bathythermographs and CTD's along the cruise track of the SSV Corwith Cramer, with stations spaced at intervals of every 20 to 40 nm. The results of the data analyzed revealed a trend of increasing depth of the mixed layer as the vessel progressed from east to west. It was also noted that the slope of the thermocline remained constant along this leg. There were no trends found in the temperature inversions, and surface temperature data remained constant. The results from Leg II lead to the identification of 18 degree Sargasso Sea water west of Pedro Bank. The results of Leg I data did not suggest any clear trends. It was hypothesized that the water coming through the passages along the Lesser Antilles resulted in variable mixed layer depths and thermocline slopes.

The Density and Distribution of Oscillatoria and its Importance as a Primary Producer in the Caribbean Sea

Kerry A. Dorton, St. Lawrence University
Kendal E. Harr, Cornell University

Abstract:

The importance of Oscillatoria as a primary producer in the Caribbean Sea has only recently been recognized with the use of modern sampling techniques. The intent of this project was to investigate the relation between the abundance of Oscillatoria and the physical characteristics of the water masses.

The density and distribution of Oscillatoria were tracked from Grenada to Roatan and the organisms that live within the cyanobacterial mats were observed under a compound light microscope. Sampling was carried out using a 65um mesh phytoplankton net towed in the upper 5 meters for 15 minutes at each station, and then the samples were filtered on to gridded filters for counting.

The denisty of Oscillatoria filaments ranged for 20 to 6441 filaments/m^3, with the highest concentrations being found at possible zones of topographic upwelling at Beata Ridge and Pedro Bank. A correlation between salinity and the abundance of Oscillatoria was also noted. Areas of higher relative salinity contained less filaments per m^3 while, in general, Oscillatoria filaments were more abundant in areas of lower relative salinity for the Caribbean Sea. Oscillatoria thrives in an environment where the temperature is between 27 and 29 degrees Celsius. At the one station where temperature fell below 27 degrees Celsius, a decreased density was found.

A large number of organisms living in association with the algal filaments was also observed, including copepods, foraminifera, pteropods, and veliger larvae. All of these observations suggested that Oscillatoria is an extremely important primary producer in the Caribbean Sea.

Diel Vertical Migration: Biomass and Diversity of Zooplankton off the Leeward Side of Grenada

Amy DuBois, Rutgers University

Abstract:

The purpose of this project was to study the diel vertical migration of zooplankton off the leeward side of Grenada and to determine the biomass and diversity of these organisms. Although the zooplankton migrate in response to variations in the depths of the isolumes, many hypotheses exist as to the reasons for this type of behavior.

Four sets of meter net tows were conducted during a 24-hour station off the leeward side of Grenada. The intervals sampled included 0 to 100m, 0 to 200m, and 0 to 500m in depth.

Changes in biomass (actually measured as biovolume) observed in each depth interval corresponded with the trends expected during diel vertical migration. Biovolume between 0 and 100m increased by 50% for the midnight tow compared with the noon tow. Copepods far outnumbered all other zooplankton and they, together with euphausiids and chaetognaths showed vertical migration patterns. Because of the abundance of copepods and their easy identification, further studies could be done on differences in the diel vertical migration of copepods.

Sediment Study of the Southern Flank of Pedro Bank

B. Clayton Gentry, University of Alabama

Abstract:

Pedro Bank, a submerged carbonate platform, is part of the Nicaraguan Rise, just southwest of Jamaica. The Bank was studied by 12 shipek grabs taken on the middle of the southern flank (~17°N x 78°20'W), on top of the bank (~17°N x 78°35-55'W), and off the western edge of the bank (~17°N x 78°W). Analyses of the samples indicated that the bank-top sediments were calcareous and derived from bottom-dwelling algae and organisms, including Halimeda, coral fragments and bivalves. These sediments also showed a bimodal size distribution, except for the sample furthest to the west, which was composed of all clay-sized sediment.

Samples taken off the bank showed a sharp increase in pelagic sediments, although fragments of bank-top material were also present. Since sediment production is actively occurring on Pedro Bank, as indicated by the recovery of benthic algae and organisms, it is likely that it will continue to grow.

Geostrophic Flow Through the Lesser Antilles

Jennifer L. Haddock, University of Rhode Island

Abstract:

Data collected from four 1000 meter CTD casts were used to calculate dynamic heights of water and geostrophic flow. The geostrophic flow equation was used to calculate the net relative velocities between three pairs of stations from St. Thomas to Grenada. The general trend was an east-west component of current except with the two stations near the Anegada Passage. Between these two stations a net velocity of zero was calculated, showing that there is no net east-west vector component to the current. This zero net velocity may suggest smaller scale currents between the two stations. The strongest surface currents were found between Dominica and Grenada agreeing with past research. The top 200 meters of the water column has the largest relative velocities because of the steady winds that are continuously blowing across the surface of the ocean. The volume transport of water was easily determined by finding the area between two stations and multiplying it by the average net relative velocity. The total volume transport of water through the passages of the Lesser Antilles was 27.1 x 10^6 m^3/s. Again, the greatest values were found between Dominica and Grenada. These values agreed with past trends. The values calculated in this study can help to determine the circulation in the eastern portions of the Caribbean.

A Comparison of the Location and Concentration of the Deep Chlorophyll Maximum in Near-Island, Open Ocean and Carbonate Bank Waters

Scott Kelley, Cornell University

Abstract:

The location and concentration of deep chlorophyll maxima were determined at 5 hydrocast stations across the Caribbean in near-island, open ocean and carbonate bank waters. Water samples were collected in Niskin bottles and analyzed for chlorophyll and phosphates. Concentration of chlorophyll in the deep chlorophyll maximum was highest closer to islands and decreased away from land masses. Chlorophyll production leeward of Pedro Bank was observed to increase relative to samples taken windward of the bank. The depth of the deep chlorophyll maxima correlated well with the depth of the thermocline and pynocline.

The Occurrence of North Atlantic Deep Water in the Caribbean Sea

Christopher W. Knowlton, Colgate University

Abstract:

North Atlantic Deep Water (NADW) is found in the Caribbean Sea between 1000-2000m and has been suggested to be very important to the renewal of the Deep Caribbean Water. The purpose of this project was to use physical and chemical characteristics of NADW to determine its distribution across the Caribbean Sea. Six hydrocasts with CTD's to a target depth of 1800m were made--one in each of the five major basins, and a second in the Cayman Basin. Concentrations of silicate, oxygen, phosphate and salinity were determined and used to identify NADW. Three of the casts went to an adequate depth to find NADW. NADW was found in the Cayman, Venezuela, and Grenada Basins at depths of 1330m to 1800+m. No previous study has found such a significant presence of NADW in the Grenada Basin.

Zooplankton Biomass vs. Diversity in the Caribbean Sea

William Leazer, Purdue University

Abstract:

This study was done to determine the relation between zooplankton biomass and diversity between St. Thomas and Grenada. Twelve zooplankton samples were collected using either a neuston or a meter net. Biovolume was measured using a volume displacement method, and diversity determined by performing counts of organisms using a dissecting microscope. In general, zooplankton biomass was found to increase while diversity decreased southwards along the leeward side of the Antilles.

Distribution of Pelagic Tar in the Caribbean

Lydia Lien, Colorado College

Abstract:

Two sources of petroleum in the ocean are from natural seeps and from anthropogenic activities. Sources, such as natural seeps, account for relatively low amounts of tar per year in the ocean. The main percentage of petroleum entering the marine environment comes from oil spills and operational discharge.

This project studied the distribution of pelagic tar along the C-109 cruise track from St. Thomas to Roatan. The data collected from neuston tows was compared with past S.E.A. data and support a trend of decline in tar concentrations in the Caribbean Sea. The average percentage of tows containing tar was 52%--a decrease of 8% from last year. In general, the amount of tar increased from east to west during the second leg of the cruise, most likely due to the westward movement of surface waters in the Caribbean.

Data were also collected on the windward and leeward shores of Carriacou and the northern and southern sides of Roatan. Macrotar was determined by visual examination of the beach below, above, and on the wrackline. On Carriacou, tar was being deposited only on the windward side, while on Roatan tar was found on both the north and south sides. This difference is probably related to each island's orientation with respect to the direction of the surface current.

Data revealed a greater concentration of tar on Roatan than Carriacou with the average coverage on Carriacou being 1% or less, while on Roatan the percentage of coverage equaled 3%. Further research should determine whether the tar levels in the Caribbean continue to decline.

The Distribution of Gambrierdiscus toxicus Found on Various Species of Algae in the Shallow Water Coral Reefs of Sandy Island

Katherine Mansfield, Mount Holyoke College

Abstract:

The purpose of this study was to determine where the ciguetera causing dinoflagellate Gambierdiscus toxicus lives in the shallow, near shore environments of Carriacou and Sandy Island. As these toxic dinoflagellates have been shown to live on various species of algae, the amount of G. toxicus found on different species was quantified by collection of the available algae, filtering processes and observation through the compound microscope.

The results of this project have shown that of the algae samples collected, G. toxicus prefers to live on Halimeda and Dilophyus guineensis (and/or Dictyota bartayresii). Of the total amount of G. toxicus dinoflagellates found, Halimeda had the most overall but, Dilophyus Guineensis had the larger concentration of G. toxicus per gram of algae. An interesting observation was that these two types of algae were often found living in association with each other.

G. toxicus overall preferred brown algae over green algae as 80% of the dinoflagellates were found on brown algae and only 20% were found on the green algae. Very few, or 7.5% G. toxicus dinoflagellates were found on Sandy Island as opposed to 92.5% found on the reef off the leeward side of Carriacou.

This study supports previous studies done on the ecological aspects of G. toxicus in both the Caribbean Sea and the Pacific Ocean.

A Study of the Distribution of Scotch-Tape
Larval Forms in the Caribbean Sea

Alison McKersie, Cornell University

Abstract:

A study of the distribution and abundance of the Scotch Tape larvae and their relation to physical and chemical factors was conducted on a December and January cruise in the Caribbean Sea. These larvae are of three distinct benthic organisms: the eel, shrimp, and spiny lobster, all of which have flat, transparent, planktonic larval forms.

The sampling of these larval organisms was done daily with neuston and meter net tows. The conditions monitored for these tows were time of day, location of tow with respect to currents and regions of upwelling, water temperature, salinity, and biomass.

Nineteen tows resulted in the collection of 71 leptocephali, 88 phyllosoma, and 67 stomatopods, most of which were collected at night in the surface layer of the water column supporting the theory of diel vertical migration. Highest abundances of these larvae correlated with regions of higher overall biomass, and there appeared to be a direct relation between regions of possible topographic upwelling and current inflows into the Caribbean Sea and the occurrence of these larvae.

Pigmentation of Zooplankton in Relation to
Diel Vertical Migration

Laura Moorhouse, Rhode Island School of Design

Abstract:

The purpose of this project was to test for any relationship between diel vertical migration and the pigmentation of zooplankton. Most studies done on DVM have involved light intensity, food quantity, and temperature as possible causal factors. My hypothesis was that zooplankton exhibiting a red color will migrate farther in the water column over a 24 hour period. Red pigmentation acts as a camouflage, as red wavelengths of light usually can not penetrate deeper than 100 meters in the water column. Meter net tows were deployed over a 24 hour period in one area, at intervals of midnight, noon, dawn, and dusk. Red, transparent, and black and white copepods were present in all tows. The red copepods showed the most migratory activity in that time period; at noon they were most abundant at the deeper depths and at midnight they were most abundant at the surface.

The Location and Profile of Subtropical Underwater Along the C-109 Cruise Track

Steve Seibel, Beloit College

Abstract:

This project investigated the distribution of subtropical underwater along the C-109 cruise track. Subtropical underwater, characterized by a salinity maximum, is formed at the surface of the Sargasso Sea and flows into the Caribbean at lower levels, entering through passages in the Antilles islands. The water mass was studied from the salinity and temperature data collected using a CTD and EBT. The data yielded salinity values that were higher than expected, with the peak salinities (37.35 ppt) recorded south of Jamaica. Along the Lesser Antilles island arc, the data showed the subtropical underwater mass thinning from north to south.

An Examination of Coral Zonation and Diversity in Comparison with Sedimentation and Depth on Two Caribbean Islands

Delius Shirley, Colgate University
John Ugoretz, University of California

Abstract:

This project expanded on previous studies of coral zonation in the Caribbean to investigate the relation between zonation and certain environmental factors. Work was centered on the Islands of Roatan, off Honduras, and Sandy Island and Carriacou, in the Grenadines. The influences possibly affecting diversity which were studied included sedimentation and depth with respect to wave action or currents. For the ease of classifying reefs in this project, low wave or current energy reefs were recognized as leeward and high energy reefs as windward. The dominant species in the study areas were mapped after visually inspecting coral along transects taken from the beach or reef crest. The sediment load and size along the transects were also catalogued. These raw data indicate that more highly sedimented, protected or gently sloping reefs (leeward) have a lower diversity and less strict zonation than the unprotected or steep reefs (windward). These patterns may be due to the inherent differences in maximum depth, sediment load, and wave action on the different types of reefs. They are most probably due to a greater depth change on windward reefs and the less vigorous wave action in the environment of protected, leeward reefs.

Zoogeographic Distribution of Euthecosomatous Pteropods in the Eastern Caribbean Sea

Francesca A. Smith, Yale University

Abstract:

The species distribution of euthecosomatous pteropods in the eastern Caribbean was studied in an attempt to distinguish zoogeographic areas. Pteropods were collected at five midnight meter net tow stations along a north/south transect from St. Thomas to Grenada. Fourteen species were identified, four of which displayed significant distributional trends. Limacina lesueuri, a subtropical species, decreased from north to south, while Limacina inflata, a cosmopolitan tropical species, increased dramatically from north to south. These species were the most abundant and indicate a large scale trend from north to south of a change in zoogeographic areas from subtropical in the north to tropical in the south. The trend may be, in part, a response to changes in the physical environment as caused by the inflow of water form different areas: the convergent water in the north, and the divergent water in the south.

The trends in the distribution of the other two prevalent species do not, however, fit the large scale trend. Limacina bulimoides is a tropical species that peaks in concentration in the middle of the north/south transect. Lamacina trochiformis, a tropical species, is found in the north and not in the south. These distribution patterns may be the result of local physical factors, such as upwelling, as well as biotic interactions, such as competition.

Although zoogeographic areas could not be specifically defined, the data provided insight into the multiple factors, both biotic and abiotic, that influence pteropod distribution.

A Study of Antarctic Intermediate Water at Various Locations in the Caribbean Sea

Frederick J. Stewart, Colby College

Abstract:

This study was aimed at investigating the distribution and physical-chemical characteristics of Antarctic Intermediate Water (AAIW) on the leeward side of the Lesser Antilles and along a transect across the Caribbean Sea. Seven CTD and hydrocast stations were completed, and temperature, salinity, phosphate and oxygen concentrations determined in order to characterize AAIW. A decrease in the depth of the salinity minimum was observed towards the north along the Lesser Antilles, and west across the Caribbean Sea, suggesting warming or mixing with the overlying water. This was supported by the temperature data, but the phosphate and oxygen concentrations showed variations indicative of the effects of other factors. The observed changes supported the hypothesis that a decrease in pure AAIW characteristics would be observed as the water moved away from the southern passages where it enters the Caribbean.

Sandy Island, Carriacou: An Exploratory Study of the Forces Affecting the Sedimentary Processes

Diana Stram, Colgate University
Rachel Tilney, Colby College

Abstract:

This project focused on the sediment distribution of Sandy Island, Carriacou, in order to evaluate the important factors influencing sedimentation. Since no previous studies had been done on Sandy Island, a secondary objective was to establish a data base for future SEA studies.

The main components of the project included a survey map of the high and low water lines of Sandy Island, a survey of the elevation of six transect lines, and a study of the composition and distribution of sediment. The transect lines ran perpendicular to the shoreline, and were approximately 10-15 feet in length, beginning at the beach and extending into the water. Sediment samples taken along the transect lines were all locally produced, and $CaCo_3$ in composition. Sediments were also found to be coarser on the windward side and finer on the leeward side of the island. Along each transect line, the sediments ranged from fine to coarse as they extended further into the water.

It is likely that wave action is responsible for the general erosional and depositional activities, while storm activity accounts for large noticeable changes in coastal morphology. Continued monitoring of the island's morphology will be necessary to determine the important sedimentary processes.

Concentrations of Chlorophyll a and Phosphate: Two Determinants of Productivity over Pedro Bank

Elizabeth A. Swanson, Fairfield University

Abstract:

The waters of Pedro Bank, a shallow carbonate platform that is part of the Nicaraguan Rise, comprise an area of high biotic pigment recorded on CZCS (Coastal Zone Color Scanner) images. It contrasts with the Caribbean Sea, an oligotrophic environment, that completely surrounds it. It was hypothesized that an "island mass" effect would be observed with the bank acting as a nutrient reservoir. Chlorophyll a and phosphate concentrations were measured to study the bank top's effect on productivity. Four hydrocasts and eleven surface stations taken windward, over, and leeward of Pedro Bank indicated an upwelling system. Surface concentrations of chlorophyll a were highest over and leeward of the bank top. Chlorophyll a values in the water column were higher to leeward than windward of the bank. Phosphate levels were higher on the surface west of the bank top. At the windward hydrocast station, a temperature inversion was found, supporting the idea of an upwelling east of Pedro Bank. Drawing from the data collected, an "island mass" effect is inferred to be present, leading to an increase in the productivity at Pedro Bank.

How Source Waters Entering the Caribbean Sea Affect the Distribution and Abundance of Halobates micans

Robert Watters, Denison

Abstract:

A study of the distribution and abundance of Halobates micans in the Caribbean Sea was conducted during a six-week cruise from St. Thomas, to Grenada, to Honduras, to Miami. This project evaluated the number of H. micans collected in 23 neuston tows conducted at noon and midnight. The data collected were analyzed to determine the distribution of H. micans, including the male to female ratio, the adult to juvenile ratio, and the difference in abundance between day and night tows. The abundance of H. micans in the day and night tows differed greatly with an average of 17.18 ± 19.59 H. micans caught in the night tows compared to 1.25 ± 1.14 caught in the day tows. These numbers coincide with past studies which have found the H. micans has the ability to actively avoid the neuston net in the daylight. More adults than juveniles were collected, possibly suggesting that this is not a period of active reproduction, and more females than males were collected along the cruise track. Although the numbers of H. micans generally increased in samples taken further southward, there are not enough data to relate distribution with water masses entering the Caribbean or to make conclusions about H. micans distribution. Combined with further studies of this type, the distribution and abundance patterns of H. micans in the Caribbean Sea can be better understood.

RESEARCH SUMMARY

The diversity of topics addressed in the student research projects make it hard to formulate a neat summary. Similarly the total amount of sampling and sample analysis precludes a simple summary (see Appendices I through VIII). The central theme of water masses, their properties, motion, and interaction was useful as the students formulated their field sampling plans and as they interpreted their results. Particularly rewarding was the richness of discussion between students during their final oral presentations as they reflected on the water mass theme. The links between biology, chemistry, geology and physical oceanography were clearly understood for the Caribbean setting. The six weeks for sampling, analysis and write-up impressed each of us in view of the complexity of the questions asked. The greatest frustration for most students was the inability to get enough data to be absolutely sure of their conclusion(s). But they certainly learned the meaning of sampling, extrapolation, and uncertainty. In that sense they all got personally introduced to the real world of oceanographic sciences.

The importance of sampling equipment and time was also a focus of much learning. The reliability, accuracy and limits of sampling frequently got in the way of understanding the oceanographic problem under investigation. Even with full success in executing a sampling plan, the data analyses usually revealed some unanticipated but critical aspect of the problem that required further examination and study. In this way most C-109 student research reports on file provide a basis for additional and more informed study of Caribbean Sea oceanography. The limited sampling time and spatial aspects seem inherent in nearly all the studies of the ocean processes.

In fact the Sea Semester program has a built-in tension between the need to sample for the scientific research and the need to educate the students about science, sampling, sailing and just surviving at sea. However on C-109 this developed into a healthy and productive tension.

In summary, the science conducted is best indicated by the student abstracts for each project reproduced in the previous section of this cruise report and the Appendices I - VII. A fuller understanding requires the reading of the generally impressive student research paper reports submitted for each project. Only one planned project failed and that was based on sampling Sargassum weed. Upon leaving St. Thomas, only sparse Sargassum was seen for a day or two. After seeing none for roughly three weeks in the eastern and central Caribbean, some more was noticed toward the end of the cruise.

CRUISE SUMMARY

The C-109 cruise clearly fulfilled both the academic program and research experience goals of a Sea Semester. The preceding listings of activities, classes, presentations, and report abstracts indicate the intensity of the program. The total number of samples collected and analyses completed reinforce this sense of accomplishment. However much of the personal growth is missed by these aspects of the cruise report. As the preface and introduction indicate, a great deal is learned which goes far beyond the formal and planned aspects of the experience.

The richness of the C-109 group dynamics was most vividly revealed by three memorable events. Starting at noon on November 30, 1989, twenty-five students boarded SSV Corwith Cramer at Charlotte Amalie, St. Thomas, and joined the staff which had assembled over the previous few days. Their student faces and bodies radiated anticipation, uncertainty, and near paralysis. While no longer on land they were clearly not one with the Cramer. All moves had to be thought-out and considered prior to execution. There was no easy flow or spontaneous action. This was understandable since there was so much to learn and we would all be at sea in just a few hours. The constant shifting to find a more comfortable perch or position was made impossible by the overwhelming number of uncertainties clouding their minds. Yet they knew that going to sea was important so "Winds" by Susan St. John Rheault and "Sea Fever" by John Masefield are opening entries in the cruise report.

On Christmas day after the severe cold-front, gale winds, and rain had passed their peak, and seas had subsided, a celebration was possible. The sumptuous traditional turkey dinner was followed by Secret-Santa gift presentations with much revelry, and "The Night Before a Corwith Cramer Christmas" was read by A-Watch. The sharing together of a ship's crew at sea was highlighted in each verse so the lines follow this summary for others to enjoy as well.

Finally, the night before debarking during the traditional farewell events, the seaworthy C-109 crew shared memories, stories, laughs and tears of both joy and sadness. All moved as one with the ship so comfortable in any perch or position not a trace of the wide-eyed fear so dominant just six weeks and 3222 logmiles prior. The words to "C-109 Diesel-Cycle Theme Ballad" and the "Corwith Cramer I Love You Well" reveal the uninhibited mood that Scully's guitar-assisted singing promoted. The final singing by the students to the staff of "The Parting Glass" was a rewarding expression of thanks to all participants, capturing our strong sense of comradeship. Thus they fittingly provide the closing words of this C-109 cruise report summary.

The Night Before a Corwith Cramer Christmas

Twas the night before Christmas
and all through the boat
only one watch was standing
to keep us afloat

The sea-boots were hung
by the galley with care
in hopes that a beer
would be found in there

The JWO's were snuggled
all sweaty in bed
while visions of biomass
danced in their heads

With Peg in the Raingear
and Charlie in mocs
we were all headed
to our next port stop

When up in the lab
there arose such a shatter
Peg ran up the stairs
said, "Tim, what's the matter"

And off to the doghouse
they flew in a flash
Turned on the radar
to avoid sudden crash

The moon on the crests
of the whitecaps did show
a hydrocast towed
from the blue depths below

When what to their wondering
eyes did appear
but a force nine gale
and A-Watch not there

With a first mate looking
so sickly and pale
they knew in a moment
he'd be over the rail

The first mate he called
his watch out by name
Come Delius, come Amy, come Chris, come John
Come Kerry, come Laura, come Ali, and Jen

To the end of the yard
to the top of the mast
haul down that main
and furl it fast

Like dry heaves before a hurricane fly
when met with an obstacle
mount to the sky

To the top of the doghouse
the JWO's they flew
with a handful of gaskets
and safety harnesses too

and then in an instant
they heard on the davit
the shaking and quaking
of EBT havoc

As they pulled up the wire
that was jerking around
"Oh shit", Nicki exclaimed
with a frown

It was only frayed wire
after 1300 foot
"Damn", they said
this does not look good

Things were seeming
a bit amuck
but it was back to the Jib
which needed to be struck

Their muscles were tired
their legs like spaghetti
Jeff yelled "What the bloody hell,"
"Aren't you ready?"

The miter they pulled
down below their knees
hoping all the while
not to drown in the rough seas

When they finished
the JWO's headed back aft
and passing, glanced warily
at the life raft

B-watch was waiting
when they arrived
glad to see
that A-watch all had survived

And they warily said
heading below at first light,
"Merry Christmas to all,"
"and to all a good night".

A-watch C-109
KD, AD, JH, CK, AMcK, LM, DS, JU

C-109 Diesel-Cycle Theme Ballad

Suck, Squeeze, Bang, Blow

by Scully

Drop all your sails
Rev your engines to go
Don't forget lubrication
Suck Squeeze Bang Blow

Tie me to the bed and said Fred
As she went down below
Slap me 'round the head said Fred
Suck Squeeze Bang Blow

CHORUS: Suck ... Squeeze Bang and Blow

Got a special relationship
Gotta place you can go
Get in synch in the engine room
Suck Squeeze Bang Blow

If you want to be a captain
John will let you know
You must know how to
Suck Squeeze Bang Blow

CHORUS

Rubbing for some friction
You're just too hot to hold
Light me with your glow plug baby
Suck Squeeze Bang Blow

Gioia's staying up all night
When the wind won't blow
Gotta way to fill your sails
Suck Squeeze Bang Blow

Intake Compression Power Exhaust

Peg's on the throttle
Moving back and forth
Making all her moves
Steering out a course

Watching the shaft
Flywheel spinning round
Baby make me hurt
Moving up and down

Let me show you, Jeff said
I'll show you where to stow
Find the hidden places
Suck Squeeze Bang Blow

CHORUS
bad sex...

Corwith Cramer I Love You Well

Zach Zodiac and the Grateful Dead
Get the hariy sponge and clean that head
"Go clean yourself as well" I said
Then hit the lab with Mr. Ed

I think I'm in lab again
With Mad Dog and the Fisherman
On second thought I'll double check
"Oh shit!" I say cause I'm on deck

Jeffy gave it to me straight
"I love it when you slobs is late,
I'll give you tasks that you will hate,"
And don't talk back to the First Mate

The captain had no wooden leg
But said we all should call her Peg
While puffin' cig's she would say
"Let's get this sucker underway"

CHORUS:
Cramer..! I love the way you hit those swells
Your delicate foc'sl smells
No vacancy in roach motels
Corwith Cramer I love you well

"Oh Rachel don't be so sensitive,"
Watch Lyd and Deb the wonder twins
Power team they activate
Tatooed lady don't be late

Now I find myself JWO
And I have to be responsible
Although things still will go
Sometimes I'd rather be below

CHORUS:
Cramer...Roxanne's still on the blink
And George he really stinks
So much that I can barely think
Corwith Cramer I love you well

~ The Parting Glass ~

Of all the money that 'ere I spent
I've spent it in good company
And all the harm that 'ere I've done
Alas, it was to none but me
And all I've done, for want of wit
To memory now I can't recall
So fill to me the parting glass
Goodnight and Joy be with you all.

Of all the comrades that 'ere I've known
Are sorry for my going away
And all the sweethearts that 'ere I've had
Will wish me one more day to stay
But since it falls into my lot
That I should rise and you should not
I'll gently rise and softly call
Goodnite and Joy be with you all.

APPENDIX I

Midnight and Noon Positions with Log

Date	Time	Log (nm)	Latitude N	Longitude W
11/30/89	00:00	Charlotte Amalie, St. Thomas, U.S. V.I.		
	12:00	Charlotte Amalie, St. Thomas, U.S. V.I.		
12/1/89	00:00	Buck's Island S. of St. Thomas		
	12:00	0000	18°16.3'	64°54.3'
12/2/89	00:00	50.8	18°08.2'	64°47.9'
	12:00	76	18°11.0'	64°32.1'
12/3/89	00:00	143.7	17°29.2'	64°05.0'
	12:00	190	16°34.6'	64°29.9'
12/4/89	00:00	231	16°50.9'	64°05.0'
	12:00	283	16°43.8'	63°28.0'
12/5/89	00:00	349	15°58.5'	62°40.5'
	12:00	389.2	15°34.0'	62°29.0'
12/6/89	00:00	445.2	15°15.0'	62°06.0'
	12:00	510.5	14°24.0'	61°51.0'
12/7/89	00:00	560.6	13°44.0'	61°51.0'
	12:00	622	12°34.5'	61°38.0'
12/8/89	00:00	644.7	12°39.0'	61°40.6'
	12:00	718	12°32.8'	61°44.8'
12/9/89	00:00	Hillsborough, Carriacou, Grenada		
	12:00	Hillsborough, Carriacou, Grenada		
12/10/89	00:00	774.8	12°19.8'	61°45.0'
	12:00			
12/11/89	00:00	St. Georges, Grenada		
	12:00	St. Georges, Grenada		
12/12/89	00:00			
	12:00	811.8	12°27.0'	61°59.5'
12/13/89	00:00	853.6	12°39.0'	62°35.9'
	12:00	898.8	13°03.6'	63°09.5'
12/14/89	00:00	929.3	13°20.0'	63°34.0'
	12:00	1019.3	14°11.5'	64°46.9'

APPENDIX I - Continued

Date	Time	Log (nm)	Latitude N	Longitude W
12/15/89	00:00	1104.4	14° 35.0'	65° 58.0'
	12:00	1163.5	14° 55.0'	66° 56.0'
12/16/89	00:00	1238.2	15° 16.0'	68° 07.8'
	12:00	1312.61	15° 29.0'	69° 14.0'
12/17/89	00:00	1381.7	15° 56.0'	70° 18.0'
	12:00	1454.4	16° 14.0'	71° 30.0'
12/18/89	00:00	1512.8	16° 33.0'	72° 42.0'
	12:00	1590.2	16° 23.2'	73° 53.0'
12/19/89	00:00	1619.1	16° 21.8'	74° 49.0'
	12:00	1677.7	16° 10.0'	76° 02.0'
12/20/89	00:00	1746.4	16° 19.0'	77° 12.0'
	12:00	1795	16° 39.5'	78° 03.0'
12/21/89	00:00	1838.3	16° 57.8'	78° 31.2"
	12:00	1868.8	17° 13.0'	78° 58.2'
12/22/89	00:00	1893.2	17° 24.7'	79° 27.4'
	12:00	1946	17° 44.0'	80° 10.0'
12/23/89	00:00	1989.3	17° 58.0'	81° 02.0'
	12:00	2015.9	17° 56.0'	81° 48.0'
12/24/89	00:00	2972.5	17° 35.5'	82° 36.8'
	12:00	2094.3	17° 09.0'	82° 52.6'
12/25/89	00:00	2111.7	16° 53'	83° 20.5'
	12:00	2156.8	16° 49.8'	84° 07.1'
12/26/89	00:00	2168.7	16° 28.77'	84° 22.83
	12:00	2205.1	16° 13.9'	85° 01.2'
12/27/89	00:00	2262.3	16° 08.2'	85° 58.8'
	12:00	2298.7	Coxen's Hole, Roatan, Honduras	
12/28/89	00:00	2316.8	Port Royal Harbor, Roatan, Honduras	
	12:00	2316.8	Port Royal Harbor, Roatan, Honduras	
12/29/89	00:00	2316.8	Port Royal Harbor, Roatan, Honduras	
	12:00	2316.8	Port Royal Harbor, Roatan, Honduras	
12/30/89	00:00	2316.8	Port Royal Harbor, Roaton, Honduras	
	12:00	2326.6	16° 13.2'	86° 16.5'

APPENDIX I - Continued

Date	Time	Log (nm)	Latitude N	Longitude W
12/31/89	00:00	2390.2	16°40.25'	86°36.1'
	12:00	2432.3	17°21.9'	86°37.5'
1/1/90	00:00	2485.9	18°32.1'	86°32.3'
	12:00	2529.6	19°26.1'	86°31.2'
1/2/90	00:00	2559.5	19°59.2'	85°38.9'
	12:00	2608.5	20°14.0'	86°30'
1/3/90	00:00	2659.9	Cozumel, Mexico	
	12:00	2659.9	Cozumel, Mexico	
1/4/90	00:00	2659.9	Cozumel, Mexico	
	12:00	2663.1	20°34.6'	87°00.8'
1/5/90	00:00	2716.0	20°56.9'	86°41.2'
	12:00	2754.8	21°08.2'	86°23.0'
1/6/90	00:00	2807.3	21°23.7'	85°57.0'
	12:00	2845.9	22°18.7'	85°52.2'
1/7/90	00:00	2882.2	22°49.1'	85°29.0'
	12:00	2938.3	23°15.8'	84°47.5'
1/8/90	00:00	3006.6	23°35.0'	83°29.5'
	12:00	3104.3	24°02.4'	81°47.9'
1/9/90	00:00	3189.9	24°46.6'	80°9.7'
	12:00	3216.3	25°38.0'	79°59.0'
1/10/90	00:00	3221.8	25°48.7'	80°44'
	12:00	NOAA Facilities, Dodge Island, Miami, Florida		

APPENDIX II

Sampling Station List

Station I.D.	Type	Date	Time	Lat. N	Long. W	Log (nm)
C-109-1	neuston tow	12/2/89	0914	17°58.0'	64°36.8'	83.7
C-109-2	hydrocast, 5 bottle; 1000m	12/2/89	2238	17°29.2'	64°31.0'	142.7
C-109-3	CTD, 1000m	12/2/89	2238	17°29.2'	64°31.0'	142.7
C-109-4	meter net tow, 200m	12/3/89	0147	17°26.5'	64°30.1'	146.3
C-109-5	neuston tow	12/3/89	1151	16°39.7'	64°22.0'	189.6
C-109-6	meter net tow, 200m	12/3/89	1329	16°34.8'	64°25.8'	195.8
C-109-7	neuston tow	12/4/89	0010	16°47.3'	64°04.3'	231.2
C-109-8	meter net tow, 200m	12/4/89	0216	16°45.0'	63°53.9'	239.4
C-109-9	CTD, 500m	12/4/89	0600	16°30.0'	63°30.0' -40.2	263.2
C-109-10	neuston tow	12/4/89	1231	16°42.8'	63°30.4'	283.6
C-109-11	meter net tow, 200m	12/4/89	2202	16°05.0'	63°12.0'	342.3
C-109-12	neuston tow	12/4/89	2352	15°58.5'	62°40.5	349.1
C-109-13	hydrocast, 9 bottle; 1800m	12/5/89	0616	15°39.5'	62°36.0'	369.4
C-109-14	CTD, 2000m	12/5/89	0616	15°39.5'	62°36.0'	369.4
C-109-15	neuston tow	12/5/89	1112	15°39.0'	62°45.0'	385.6
C-109-16	meter net tow, 200m	12/5/89	1250	15°44.0'	62°30.0'	392.1
C-109-17	neuston tow	12/5/89	2326	15°26.0'	62°10.0'	444.1
C-109-18	meter net tow, 200m	12/6/89	0027	15°15.0'	62°06.0'	446.3
C-109-19	CTD, 500m	12/6/89	0620	14°42.8'	61°54.3'	485.5
C-109-20	neuston tow	12/6/89	1103	14°22.1'	61°50.3'	506.1
C-109-21	meter net tow, 200m	12/6/89	1203	14°23.0'	61°51.0'	510.3
C-109-22	hydrocast, 5 bottle; 1000m	12/6/89	1940	13°41.0'	61°46.0'	553.2
C-109-23	CTD, 1300m	12/6/89	1940	13°41.0'	61°46.0'	553.2
C-109-24	neuston tow	12/6/89	2300	13°34.6'	61°52.0'	559.5
C-109-25	meter net tow, 209 m	12/7/89	0028	13°30.9'	61°49.7'	561.8
C-109-26	meter net tow, 100; 200; 500m	12/7/89	1200	12°34.5'	61°38.2'	622.3
C-109-27	meter net tow, 100m	12/7/89	1752	12°32.2'	61°37.0'	642.7
C-109-28	hydrocast, 5 bottle; 1000m	12/7/89	2105	12°30.8'	61°39.4'	644.6
C-109-29	CTD, 1400m	12/7/89	2105	12°30.8'	61°39.4'	644.6
C-109-30	meter net tow, 100; 200; 500m	12/8/89	0015	12°28.4'	61°40.8'	644.7
C-109-31	meter net tow, 100m	12/8/89	0659	12°30.0'	61°41.4'	714.4

Station I.D.	Type	Date	Time	Lat. N	Long. W	Log (nm)
C-109-32	hydrocast, 12 bottle; 200m	12/8/89	1000	12°30.0'	61°41.4'	715.4
C-109-33	CTD, 200m	12/8/89	1009	12°30.0'	61°41.4'	715.4
C-109-34	meter net tow, 200m	12/12/89	1214	12°22.0'	62°03.0'	812.5
C-109-35	neuston tow	12/13/89	1325	13°06.6'	63°09.5'	899.0
C-109-36	CTD, 500m	12/13/89	1525	13°03.7'	63°09.8'	900.3
C-109-37	hydrocast, 200m; 12 bottle	12/13/89	1525	13°03.7'	63°09.8'	900.3
C-109-38	hydrocast, 1800m; 9 bottle	12/15/89	0730	14°57.9'	66°43.7'	1156.2
C-109-39	CTD, 1800m	12/15/89	0730	14°57.9'	66°43.7'	1156.2
C-109-40	neuston tow	12/15/89	1200	14°56.0'	66°45.0'	1162.6
C-109-40A	phytoplankton tow					
C-109-41	neuston tow	12/16/89	0000	15°16.3'	66°07.8'	1238.8
C-109-42	CTD, 500m	12/16/89	0843	15°32.1'	69°00'	1293.7
C-109-43	meter net tow, 200m	12/16/89	1210	15°30'	69°15'	1312.3
C-109-44	phytoplankton tow	12/16/89	1210	15°30'	69°15'	1312.3
C-109-45	meter net tow, 200m	12/17/89	0030	15°56.2'	70°18.0'	1382.4
C-109-46	phytoplankton tow	12/17/89	0100	15°56.2'	70°18.0'	1383.4
C-109-47	neuston tow	12/17/89	1130	16°14.0'	71°28.0'	1453.5
C-109-48	hydrocast, 150m; 12 bottle	12/17/89	1220	16°17.1'	71°38.4'	1454.5
C-109-49	CTD, 500m	12/17/89	1220	16°17.1'	71°38.4'	1454.5
C-109-50	phytoplankton tow	12/17/89	1220	16°17.1'	71°38.4'	1454.5
C-109-51	neuston net tow	12/18/89	0007	16°33'	72°42'	1513.6
C-109-52	meter net tow, 200m	12/18/89	1200	16°12.1'	73°57.1'	1590.7
C-109-53	hydrocast, 1800m; 10 bottle	12/18/89	1320	16°13'	73°57'	1591.8
C-109-54	CTD, 1800m	12/18/89	1320	16°13'	73°57'	1591.8
C-109-55	meter net tow, 200m	12/19/89	0040	16°21.8'	74°49'	1621.1
C-109-56	phytoplankton tow	12/19/89	0040	16°21.8'	74°49'	1621.1
C-109-57	CTD, 500m	12/19/89	1049	16°08'	76°00'	1677.1
C-109-58	neuston tow	12/19/89	1150	16°12'	75°50'	1677.4
C-109-59	neuston tow	12/20/89	0031	16°19.0'	77°12.0'	1748.6
C-109-60	hydrocast, 200m; 12 bottle	12/20/89	0640	16°32.2'	77°38.2'	1776.6
C-109-61	CTD, 500m	12/20/89	0640	16°32.2'	77°38.2'	1776.6
C-109-62	meter net tow, 200m	12/20/89	1052	16°36.5'	78°01.5'	1794.4

Station I.D.	Type	Date	Time	Lat. N	Long. W	Log (nm)
C-109-63	phytoplankton tow	12/20/89	1200	16°39.5'	78°03.0'	1795.6
C-109-64	shipek, 31m	12/20/89	1500	16°49.0'	78°18.7'	1810.5
C-109-65	shipek, 285m	12/20/89	1530	16°49.2'	78°18.9'	1811.2
C-109-66	shipek, 208m	12/20/89	1615	16°45.0'	78°15.5'	1811.6
C-109-67	shipek, 498m	12/20/89	1700	16°44.2'	78°16.5'	1812.0
C-109-68	shipek, 465m	12/20/89	1930	16°53.0'	78°22.5'	1822.4
C-109-69	hydrocast, 15m; 4 bottle	12/20/89	2013	16°53.0'	78°22.5'	1822.5
C-109-70	CTD, 15m	12/20/89	2013	16°53.0'	78°22.5'	1822.5
C-109-71	shipek, 1400m	12/20/89	2300	16°57.8'	78°31.2'	1833.1
C-109-72	hydrocast, 17m; 4 bottle	12/20/89	2330	16°57.8'	78°31.2'	1833.1
C-109-73	CTD, 17m	12/20/89	2330	16°57.8'	78°31.2'	1833.1
C-109-74	phytoplankton tow	12/20/89	2350	16°57.8'	78°31.2'	1833.3
C-109-75	neuston tow	12/21/89	0005	16°57.8'	78°31.2'	1833.4
C-109-76	shipek, 19m	12/21/89	0512	17°04.4'	78°54.3'	1851.9
C-109-77	shipek, 20m	12/21/89	0618	17°03.8'	78°55.6'	1853.3
C-109-78	shipek, 37m	12/21/89	0700	17°03.8'	78°55.4'	1853.3
C-109-79	shipek, 280m	12/21/89	0742	17°03.5'	78°56.7'	1853.3
C-109-80	phytoplankton tow	12/21/89	1225	17°14.7'	78°58.4'	1870.0
C-109-81	neuston tow	12/21/89	1249	17°14.1'	78°58.4'	1869.8
C-109-82	meter net tow, 200m	12/21/89	1326	17°15.1'	78°59.2'	1872.5
C-109-83	hydrocast, 200m; 12 bottle	12/21/89	1650	17°18.0'	79°14.0'	1822.2
C-109-84	CTD, 500m	12/21/89	1650	17°18.0'	79°14.0'	1882.2
C-109-85	neuston tow	12/21/89	2350	17°24.7'	79°27.4'	1893.2
C-109-86	phytoplankton tow	12/22/89	0045	17°25.5'	79°29.0'	1894.9
C-109-87	meter net tow, 250m	12/22/89	1300	17°47.5'	80°10.0'	1947.1
C-109-88	phytoplankton tow	12/22/89	1300	17°47.5'	80°10.0'	1947.1
C-109-89	hydrocast, 1800m; 9 bottle	12/22/89	2200	18°00.7'	80°58.5'	1989.3
C-109-90	CTD, 1800m	12/22/89	2200	18°00.7'	80°58.3'	1989.3
C-109-91	phytoplankton tow	12/22/89	2325	18°00.7'	80°58'	1989.3
C-109-92	neuston tow	12/23/89	0226	17°57.5'	81°03.6'	1989.5
C-109-93	CTD, 500m	12/23/89	0850	18°01.0'	81°34'	2007.6
C-109-94	neuston tow	12/23/89	1330	17°59.8'	81°49.5'	2019.2

Station I.D.	Type	Date	Time	Lat. N	Long. W	Log (nm)
C-109-95	phytoplankton tow	12/23/89	1405	17°59.8'	81°49.5'	2020.5
C-109-96	neuston tow	12/25/89	1100	16°43.0'	84°04.5'	2154.0
C-109-97	phytoplankton tow	12/25/89	1200	16°39'	84°01'	2156.8
C-109-98	CTD, 500m	12/25/89	2040	16°33.1'	84°19.1'	2168.2
C-109-99	phytoplankton tow	12/26/89	0000	16°28.2'	84°22.8'	aboard
C-109-100	neuston tow	12/26/89	0250	16°22.7'	84°23.2'	2168.9
C-109-101	shipek, 750m	12/26/89	1130	16°15.0'	85°02.0'	2205.1
C-109-102	shipek, 550m	12/26/89	1200	16°08.8'	85°01.2'	2205.1
C-109-103	shipek, 375m	12/26/89	1322	16°09.7'	85°01'	2206.8
C-109-104	shipek, 320m	12/26/89	1355	16°08.9'	85°01.3'	2207.6
C-109-105	meter net tow, 200m	12/27/89	0149	16°11.5'	86°03.0'	2268.1
C-109-106	phytoplankton tow	12/27/89	0230	16°11.5'	86°03.0'	2268.1
C-109-107	CTD, 500m	12/30/89	1153	16°18.1'	86°16.5'	2326.5
C-109-108	meter net tow, 200m	12/30/89	1245	16°12.4'	86°18.3'	2326.8
C-109-109	meter net tow, 200m	12/31/89	0130	16°43.8'	86°34.1'	2396.1
C-109-110	hydrocast, 6 bottle; 1800m	12/31/89	0345	16°49.3'	86°36.0'	2400.0
C-109-111	CTD, 1800m	12/31/89	0410	16°49.3'	86°36.0'	2400.0
C-109-112	neuston tow	12/31/89	1200	17°21.9'	86°37.5'	2433.7
C-109-113	neuston tow	12/31/89	2338	18°28.0'	86°32.5'	2485.5
C-109-114	CTD, 500m	1/1/90	0035	18°28.0'	86°32.5'	2485.5
C-109-115	meter net tow, 200m	1/1/90	1325	19°30.0'	86°41.2'	2532.9
C-109-116	CTD, 500m	1/1/90	2120	19°58.5'	86°41.3'	2556.1
C-109-117	meter net tow, 200m	1/1/90	2345	20°00.0'	86°39.5'	2559.2
C-109-118	CTD, 400m	1/2/90	0950	20°05.0'	86°20.0'	2597.5
C-109-119	neuston net tow	1/4/90	1230	20°36.0'	86°01.0'	2664.8
C-109-120	neuston net tow	1/5/90	0004	20°56.9'	86°41.2'	2716.3
C-109-121	meter net tow, 150m	1/5/90	1418	21°10.3'	86°19.2'	2762.2
C-109-122	meter net tow, 200m	1/6/90	0025	21°23.7'	85°57.0'	2807.3
C-109-123	CTD, 1800m	1/6/90	0205	21°23.4'	85°55.7'	2809.7
C-109-124	hydrocast, 6 bottle, 1800m	1/6/90	0205	21°23.4'	85°55.7'	2809.7

APPENDIX III

Surface Stations

Sta. #	Date	Time	Lat. N	Long. W	Log (nm)	Temp. °C	Salinity (°/oo)	Chl a (ug/l)	Phosphate (µM)
1	12/2/89	1245	18°10.0'	64°32.0'	100.0	27.8	35.127	0.066	0.775
2	12/2/89	1712	17°50.0'	64°31.2'	120.0	27.8	35.061	0.120	0.426
3	12/2/89	2246	17°29.2'	64°30.0'	142.7	27.8	34.891	0.072	0.468
4	12/3/89	0600	17°06.3'	64°26.2'	161.0	27.8	34.687	0.069	0.193
5	12/3/89	1035	16°49.8'	64°28.8'	180.5	27.5	35.041	0.070	0.201
6	12/3/89	1545	16°34.0'	64°24.0'	206.0	28.1	34.999	0.070	0.158
7	12/3/89	2145	16°47.3'	64°15.5'	221.4	28.2	35.147	0.066	0.173
8	12/4/89	0248	16°45.0'	63°54.0'	240.1	27.8	35.462	0.121	0.607
9	12/4/89	0427	16°37.3'	63°37.8'	252.1	27.9	35.500	lost	0.196
10	12/4/89	1113	16°40.8'	63°33.0'	281.0	28.1	35.003	0.076	0.379
11	12/4/89	1700	16°39.0'	63°26.0'	304.6	28.4	35.208	0.085	0.301
12	12/4/89	1930	16°22.0'	63°07.5'	321.5	28.1	35.031	0.082	0.134
13	12/5/89	0110	15°58.5'	62°40.5	351.6	28.2	35.249	0.095	0.056
14	12/5/89	0610	15°39.5'	62°36.0'	369.4	28.1	35.311	0.123	0.268
15	12/5/89	1700	15°46.0'	62°24.4'	407.4	28.3	35.280	0.079	0.299
16	12/5/89	2010	15°09.0'	62°16.0'	420.1	28.1	35.113	0.058	0.199
17	12/5/89	2250	15°09.0'	62°02.0'	440.1	27.7	34.976	0.121	0.399
18	12/6/89	0329	15°03.2'	62°01.5'	465.9	27.7	35.314	0.106	0.455
19	12/6/89	0518	15°48.4'	61°55.0'	480.4	27.7	35.676	0.096	0.523
20	12/6/89	1200	14°23.0'	61°51.0'	510.3	27.9	35.745	0.123	0.974
21	12/6/89	2200	13°38.3'	61°52.8'	554.9	27.8	35.669	0.218	0.375
22	12/7/89	0530	13°11.0'	61°49.5	581.7	27.9	35.438	0.225	0.185
23	12/8/89	0708	12°30.0'	61°49.5'	715.3	27.9	lost	0.206	0.449
24	12/12/89	2245	12°33.2'	62°28.8'	845.8	27.8	35.357	0.054	0.000
25	12/13/89	0420	12°53.0'	63°03.0'	881.8	27.7	34.372	0.304	0.020
26	12/15/89	1804	15°10.0'	67°27.0'	1195.7	28.1	34.864	0.328	0.080
27	12/16/89	0103	15°08.6'	68°05.1'	1240.0	27.7	34.723	0.281	0.025
28	12/16/89	0622	15°23.9'	68°45.4'	1277.8	27.4	34.974	0.204	0.550
29	12/16/89	1430	15°23.7'	69°14.9'	1317.5	27.4	35.240	0.106	0.109
30	12/16/89	2030	15°55.0'	69°56.0'	1359.4	27.3	34.971	0.099	0.044
31	12/17/89	0414	16°01.3'	70°39.8'	1405.8	27.6	34.800	0.073	0.177
32	12/17/89	1215	16°17.1'	71°17.1'	1454.5	27.8	34.128	0.077	0.217

Sta. #	Date	Time	Lat. N	Long. W	Log (nm)	Temp. °C	Salinity (°/oo)	Chl a (ug/l)	Phosphate (µM)
33	12/17/89	2100	16°24.2'	72°28.8'	1494.9	27.5	35.677	0.771	0.177
34	12/18/89	0355	16°35.5'	73°10.8'	1535.4	28.0	35.267	0.101	0.016
35	12/18/89	1000	16°25.3'	73°48.8'	1575.3	28.1	35.227	0.102	0.096
36	12/18/89	1900	16°12.0'	74°25.0'	1592.2	27.8	35.445	0.224	2.450
37	12/19/89	0150	16°16.0'	74°49.5'	1623.0	27.8	35.393	0.109	0.358
38	12/19/89	0814	16°08.0'	75°43.0'	1661.6	27.5	35.990	0.244	0.800
39	12/19/89	1930	16°06.2'	76°46.3'	1718.8	27.8	35.591	0.144	0.251
40	12/20/89	0120	16°20.3'	77°14.0'	1750.2	27.9	35.331	0.140	0.192
41	12/20/89	0700	16°32.2'	77°38.2'	1777.6	27.1	35.353	0.147	0.000
42	12/20/89	2013	16°53.0'	78°22.5'	1822.5	27.9	35.182	0.334	0.139
43	12/20/89	2300	16°57.8'	78°31.2'	1833.1	27.9	35.149	0.199	0.000
44	12/21/89	0315	17°02.8'	78°46.1'	1843.3	27.9	35.154	0.147	0.029
45	12/21/89	0520	17°04.4'	78°54.3'	1851.9	27.9	35.157	0.128	0.025
46	12/21/89	0805	17°03.9'	78°56.2'	1854.2	28.1	35.178	0.215	0.864
47	12/21/89	1120	17°12.1'	78°51.4'	1865.1	28.2	35.202	0.178	0.358
48	12/21/89	1440	17°24.1'	79°01.7'	1875.3	28.2	35.234	0.155	0.169
49	12/21/89	1733	17°18.0'	79°14.0'	1884.3	28.3	35.326	0.091	0.021
50	12/22/89	0639	17°36.6'	79°51.0'	1921.5	28.0	35.766	0.118	0.677
51	12/22/89	1642	17°54.0'	80°35.5'	1965.5	28.2	35.567	0.222	0.143
52	12/23/89	1330	17°59.8'	81°49.5'	2019.2	28.2	35.316	0.130	0.165
53	12/23/89	2120	17°51.0'	82°19.0'	2051.9	28.1	35.778	0.090	0.115
54	12/25/89	0845	16°44.4'	84°00.0'	2147.0	27.6	35.924	0.084	0.411
55	12/26/89	0045	16°28.3'	84°22.8'	2168.2	27.3	35.784	0.284	0.326
56	12/26/89	1905	16°09.5'	85°24.6'	2232.2	26.7	35.401	0.318	0.160
57	12/27/89	0330	16°12.0'	86°08.6'	2272.7	26.4	35.622	0.336	0.188
58	12/31/89	0410	16°49.3'	86°36.0'	2400.0	26.9	lost	0.197	0.133
59	12/31/89	0410	17°30.5'	86°35.5'	2440.0	27.1	35.455	lost	0.078
60	1/1/90	0035	18°28.0'	86°37.5'	2485.8	26.9	35.491	0.122	0.295
61	1/1/90	1035	19°20.5'	86°31.2'	2524.8	27.5	35.807	0.125	lost
62	1/1/90	2120	19°58.5'	86°41.3'	2556.1	27.4	35.707	0.101	0.005
63	1/2/90	0950	20°05.0'	86°20.0'	2597.5	27.4	not done	0.132	0.340
64	1/5/90	0035	20°51.1'	86°41.5'	2717.5	26.7	not done	0.235	lost
65	1/5/90	1715	21°19.2'	86°14.6'	2770.3	27.0	not done	0.127	lost
66	1/6/90	0300	21°23.4'	85°55.7'	2809.7	26.8	not done	0.115	0.628

APPENDIX IV

EBT and MBT Sampling Tabulation

Sample #	Date	Time	Lat. N	Long. W	Log (nm)	Surface Temp. °C	Maximum Depth	
							Meters	Temp. °C
EBT-1	12/1/89	1638	17°57.4'	64°54.8'	21.3	27.93	232.5	18.76
EBT-2	12/1/89	2110	17°54.5'	64°50.8'	40.6	27.25	356.4	15.68
EBT-3	12/2/89	0220	18°04.3'	64°42.6'	60.0	27.58	330.5	16.42
EBT-4	12/2/89	0618	17°53.4'	64°30.9'	68.5	27.34	377.5	15.48
EBT-5	12/2/89	1245	18°10.5'	64°32.2'	100.00	27.63	361.0	15.96
EBT-6	12/2/89	1712	17°50.0'	64°31.2'	120.6	27.8	EBT	LOST
MBT-7	12/3/89	1545	16°34.0'	64°24.0'	206.0	28.1	195	14.0
MBT-8	12/3/89	2145	16°47.3'	64°15.5'	222.2	28.0	275	16.7
MBT-9	12/4/89	0427	16°37.3'	63°37.8'	252.1	27.9	131	22.5
MBT-10	12/4/89	1113	16°40.9'	63°33.0'	281.0	28.1	275	17.0
MBT-11	12/4/89	1735	16°34.0'	63°12.0'	308.0	28.3	197	19.3
MBT-12	12/4/89	1930	16°22.0'	63°07.5'	321.5	28.1	265	16.5
MBT-13	12/5/89	0135	15°58.9'	62°43.6'	351.9	28.1	275	16.0
MBT-14	12/5/89	1700	15°46.0'	62°24.4'	407.4	28.3	275	15.8
MBT-15	12/5/89	1020	15°33.0'	62°16.0'	420.1	28.1	275	16.0
MBT-16	12/5/89	2334	15°26.0'	62°10.0'	444.2	27.9	275	15.0
MBT-17	12/6/89	0329	15°03.2'	62°01.5'	465.9	27.7	255	16.7
MBT-18	12/6/89	0518	14°48.4'	61°55.0'	480.4	27.6	275	15.6
MBT-19	12/6/89	1110	14°23.0'	61°51.0'	506.0	27.9	269	15.0
MBT-20	12/7/89	0530	13°11.0'	61°49.5'	585.5	27.9	235	14.5
MBT-21	12/8/89	1000	12°30.0'	61°41.4'	715.4	27.9	245	14.5
EBT-22	12/12/89	2245	12°33.2'	60°28.8'	845.8	27.51	98.6	23.58
EBT-23	12/13/89	0420	12°53'	63°03'	881.8	26.58	265.9	14.77
EBT-24	12/15/89	1804	15°10'	67°27'	1195.7	27.48	185.8	22.63
EBT-25	12/16/89	0103	15°08.6'	68°05.1'	1240.0	26.80	294.6	16.99
EBT-26	12/16/89	0622	15°23.9'	68°45.4'	1277.8	26.46	355.6	14.21
EBT-27	12/16/89	1430	15°23.7'	69°14.9'	1317.5	27.86	177.8	20.71

Sample #	Date	Time	Lat. N	Long. W	Log (nm)	Surface Temp. °C	Maximum Depth	
							Meters	Temp. °C
EBT-28	12/16/89	2030	15°55'	69°56'	1359.4	26.98	182.5	21.98
EBT-29	17/17/89	0414	16°01.3'	70°39.8'	1405.8	26.84	140.0	24.02
EBT-30	12/17/89	2100	16°24.2'	72°28.8'	1494.9	27.32	435.5	13.15
EBT-31	12/18/89	0355	16°33.5'	73°10.8'	1535.4	27.80	257.9	18.63
EBT-32	12/18/89	1000	16°25.3'	73°48.8'	1575.3	28.30	420.0	15.13
EBT-33	12/19/89	0150	16°16'	74°49.5'	1623.0	27.08	286.1	17.60
EBT-34	12/19/89	0814	16°08.0'	75°43.0'	1661.6	27.42	177.4	23.40
EBT-35	12/19/89	1930	16°06.2'	76°46.3'	1718.8	27.56	186.8	22.65
EBT-36	12/20/89	0120	16°20.3'	77°14.0'	1750.2	26.68	446.6	13.54
EBT-37	12/22/89	0639	17°36.6'	79°51.0'	1921.5	27.44	416.3	14.78
EBT-38	12/22/89	1030	17°45'	80°07'	1939.8	27.94	299.8	18.45
EBT-39	12/22/89	1642	17°54.0'	80°35.5'	1965.5	28.20	320.6	18.23
EBT-40	12/23/89	2042	17°54'	82°13.4'	2047.0	26.94	316.9	14.11
EBT-41	12/25/89	0845	16°44.4'	84°00.0'	2147.0	23.77	409.1	11.06
EBT-42	12/26/89	0045	16°28.3'	84°22.8'	2168.2	21.75	440.0	11.28
EBT-43	12/31/89	1410	17°30.5'	86°35.5'	2440.0	25.25	285.3	15.48
EBT-44	1/1/90	1035	19°20.5	86°31.2'	2524.8	27.90	217.6	20.05
EBT-45	1/2/89	0950	20°05'	86°20'	2597.5	27.14	440.3	13.95
EBT-46	1/5/90	0035	20°51.1'	86°41.5'	2717.5	25.65	344.6	10.70
EBT-47	1/5/90	1715	21°19.2'	86°14.6'	2770.3	26.86	224.3	15.88

APPENDIX V

Meter Net Tow Tabulations

Station #	Date	Time	Lat. N	Long. W	Depth (m)	Biomass Density (ml/1000m^3)
C109-4	12/3/89	0147	17• 26.5'	64• 30.1'	200	6.4
C109-6	12/3/89	1329	16• 34.8'	64• 25.8'	200	10.0
C109-8	12/4/89	0126	16• 45.0'	63• 53.9'	200	20.4
C109-11	12/4/89	2202	16• 05.0'	63• 12'	200	36.6
C109-16	12/5/89	1250	15• 44.0'	62• 30.0'	200	31.2
C109-18	12/6/89	0027	15• 15'	62• 06'	200	31.3
C109-21	12/6/89	1203	14• 23'	61• 51'	200	27.5
C109-25	12/7/89	0028	13• 30.9'	61• 49.6'	209	38.0
C109-26-1	12/7/89	1220	12• 34.5'	61• 38.2'	500	29.7
C109-26-2	12/7/89	1248	12• 34.5'	61• 38.2'	200	71.5
C109-26-3	12/7/89	1300	12• 34.5'	61• 38.2'	100	102.0
C109-27	12/7/89	1752	12• 32.2'	61• 37'	100	109.5
C109-30-1	12/8/89	0015	12• 28.4'	61• 40.8'	500	13.4
C109-30-2	12/8/89	0042	12• 28.4'	61• 40.8'	200	61.3
C109-30-3	12/8/89	0157	12• 28.4'	61• 40.8'	100	161.0
C109-31	12/8/89	0635	12• 30'	61• 41.4'	100	149.1
C109-34	12/12/89	1214	12• 22'	62• 03'	200	35.6
C109-43	12/16/89	1210	15• 30'	69• 15'	200	27.5
C109-45	12/16/89	0000	15• 55'	70• 12.1	200	34.7
C109-52	12/18/89	1214	16• 12.1'	73• 57.1'	200	23.5
C109-55	12/19/89	0040	16• 21.8'	74• 49.0'	200	22.9
C109-62	12/20/89	1052	16• 36.5'	78• 01.5'	200	36.2
C109-82	12/21/89	1326	17• 15.1'	78• 59.2'	200	25.2
C109-87	12/22/89	1155	17• 49.6'	80• 12.5'	250	49.9
C109-105	12/27/89	0149	16• 11.5'	86• 03.0'	200	23.9
C109-108	12/30/90	1245	16• 12.4'	86• 18.3'	200	13.2
C109-109	12/31/89	0130	16• 43.8'	86• 34.1'	200	23.5
C109-115	1/1/90	1325	19• 30.0'	86• 41.2'	200	38.1
C109-117	1/1/90	2345	20• 00.0'	86• 39.5'	200	47.97
C109-121	1/5/90	1415	21• 10.3'	86• 19.2'	150	23.8
C109-122	1/6/90	0025	21• 23.7'	85• 57.0'	194	39.5

APPENDIX VI

Neuston Net Tow Tabulation

Station	Date	Time	Latitude N	Longitude W	Biomass Density (ml/1000m^3)
C-109-01	12/2/89	0902	17• 58.0'	64• 36.8'	1.6
C-109-05	12/3/89	1151	16• 39.7'	64• 22.0'	1.1
C-109-07	12/4/89	0012	16• 47.3'	64• 04.3'	7.6
C-109-10	12/4/89	1231	16• 42.9'	63• 30.4'	0.2
C-109-12	12/4/89	2352	15• 58.5'	62• 40.5'	8.1
C-109-15	12/5/89	1112	15• 39.0'	62• 45.0'	1.1
C-109-17	12/5/89	2326	15• 26.0'	62• 10.0'	5.4
C-109-20	12/6/89	1103	14• 22.1'	61• 50.3'	1.6
C-109-24	12/6/89	2300	13• 34.6'	61• 52.0'	6.4
C-109-35	12/13/89	1325	13• 06.6'	63• 09.5'	10.8
C-109-40	12/15/89	1200	14• 56.0'	66• 45.0'	1.0
C-109-41	12/16/89	0000	15• 16.3'	68• 07.8'	7.0
C-109-47	12/17/89	1130	16• 14.0'	71• 28.0'	0.5
C-109-51	12/18/89	0007	16• 33.0'	72• 47.0'	4.3
C-109-58	12/19/89	1150	16• 12.0'	75• 50.0'	1.1
C-109-59	12/20/89	0031	16• 19.0'	72• 12.0'	11.2
C-109-75	12/21/89	0005	16• 57.8'	78• 31.2'	12.8
C-109-81	12/21/89	1220	17• 14.1'	78• 58.4'	0.5
C-109-85	12/21/89	2350	17• 24.7'	79• 27.4'	10.8
C-109-92	12/23/89	0226	17• 57.5'	81• 03.6'	16.2
C-109-94	12/23/89	1334	17• 59.8'	81• 49.5'	0.9
C-109-96	12/25/89	1643	16• 43.0'	84• 04.5'	1.2
C-109-100	12/26/89	0250	16• 22.7'	84• 23.2'	9.7
C-109-112	12/31/89	1220	17• 21.9'	86• 37.5'	18.9
C-109-113	12/31/89	2330	18• 28.0'	86• 32.5'	42.4
C-109-119	1/4/90	1230	20• 36.0'	86• 01.0'	1.1
C-109-120	1/5/89	0004	20• 56.9'	86• 41.2'	2.7

APPENDIX VII

Phytoplankton Net Tow Tabulation

Station #	Date	Time	Lat. N	Long. W	Log (nm)	Oscillatorion Fillaments/m^3	S °/oo	Chla ug/l	PO_4 µm/l
C-109-40	12/15/89	1200	14°56.0'	66°46.5'	1195.7	1632	34.86	0.328	0.08
C-109-44	12/16/89	1210	15°30.0'	69°15'	1312.3	866	35.24	0.106	0.109
C-109-46	12/17/89	0100	15°55.0'	70°12.1'	1405.8	291	34.80	0.073	NA
C-109-50	12/17/89	1220	16°17.1'	71°38.4'	1454.5	3052	34.13	0.077	NA
C-109-56	12/19/89	0040	16°21.8'	74°49'	1621.1	75	35.15	0.101	0.016
C-109-59	12/20/89	0031	16°19.0'	77°12.0'	1748.6	6441	35.33	0.140	0.192
C-109-63	12/20/89	1200	16°39.5'	78°03.0'	1795.6	977	35.35	0.147	NA
C-109-74	12/20/89	2350	16°57.8'	78°31.2'	1833.3	456	35.15	0.147	0.029
C-109-80	12/21/89	1225	17°14.7'	78°58.4'	1870.0	249	35.20	0.178	0.358
C-109-86	12/22/89	0045	17°25.5'	79°29.0'	1894.9	40	35.77	0.118	0.677
C-109-88	12/22/89	1300	17°47.5'	80°10.0'	1947.1	213	35.57	0.222	NA
C-109-91	12/22/89	2325	18°00.7'	80°58'	1989.3	211	35.32	0.13	0.165
C-109-95	12/23/89	1405	17°59.8'	81°49.5'	2020.5	247	35.32	0.13	0.165
C-109-97	12/25/89	1200	16°39'	84°01'	2156.8	20	35.92	0.084	0.411
C-109-99	12/26/89	0000	16°28.2'	84°22.8'	2168.2	174	35.78	0.284	0.323
C-109-106	12/27/89	0230	16°11.5'	86°03.0'	2268.1	18	35.00	0.336	0.188